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Regular-Soda Intake Independent of Weight Status Is Associated with Asthma among US High School Students

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Abstract

Limited research shows an inconclusive association between soda intake and asthma, potentially attributable to certain preservatives in sodas. This cross-sectional study examined the association between regular (nondiet)-soda intake and current asthma among a nationally representative sample of high school students. Analysis was based on the 2009 national Youth Risk Behavior Survey and included 15,960 students (grades 9 through 12) with data for both regular-soda intake and current asthma status. The outcome measure was current asthma (ie, told by doctor/nurse that they had asthma and still have asthma). The main exposure variable was regular-soda intake (ie, drank a can/bottle/glass of soda during the 7 days before the survey). Multivariable logistic regression was used to estimate the adjusted odds ratios for regular-soda intake with current asthma after controlling for age, sex, race/ethnicity, weight status, and current cigarette use. Overall, 10.8% of students had current asthma. In addition, 9.7% of students who did not drink regular soda had current asthma, and 14.7% of students who drank regular soda three or more times per day had current asthma. Compared with those who did not drink regular soda, odds of having current asthma were higher among students who drank regular soda two times per day (adjusted odds ratio = 1.28; 95% CI 1.02 to 1.62) and three or more times per day (adjusted odds ratio = 1.64; 95% CI 1.25 to 2.16). The association between high regular-soda intake and current asthma suggests efforts to reduce regular-soda intake among youth might have benefits beyond improving diet quality. However, this association needs additional research, such as a longitudinal examination.

Keywords

Soda; Adolescents; Asthma; Youth Risk Behavior Survey (YRBS)

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

The consumption of calorically sweetened beverages has increased during the past 20 to 30 years, with an increase from 287 kcal/day in 1988–1994 to 301 kcal/day in 1999–2004 among US adolescents aged 12 to 19 years.[1] This increase of energy intake of 14 kcal/day without expenditure through physical activity might lead to an eventual weight gain of about 1.4 lb, with half of the total weight change being achieved in approximately 1 year and 95% of the total weight change in approximately 3 years.[2] Regular soda is the most commonly consumed calorically sweetened beverage among adolescents (about 67% of all calorically sweetened beverage calories).[1] In 2005–2008, Ogden and colleagues[3] reported that 70% of boys and 60% of girls aged 2 to 19 years drank calorically sweetened beverages on any given day, and the 2010 national Youth Physical Activity and Nutrition Study found 24.3% of US high school students reported drinking regular soda one or more times per day.[4] In addition, the highest consumers of calorically sweetened beverages include adolescents, particularly males, non-Hispanic blacks, those from low-income families, and those who are obese.[1,3,5]

During the last 30 years, the prevalence of asthma has increased and is currently one of the most common chronic diseases among US children and adolescents.[6] Self-reported asthma prevalence during the preceding 12 months in 1980 was 3.5%, whereas current asthma prevalence in 2004 was 8.5% among US youth aged younger than 18 years.[7] The most current data indicate that in 2009, >10 million US youth aged 17 years and younger (14%) had ever been diagnosed with asthma, and 7.1 million children still had asthma (10%).[6] In addition, in 2007, there were 640,000 emergency department visits and 157,000 hospitalizations for asthma in US youth aged 17 years and younger.[8] In the United States, asthma-related medical expenses, including lost school and work days and early deaths, were estimated at about $56 billion in 2007.[9] Evidence suggests that, among children, males, non-Hispanic blacks, and/or children from low-income families are more likely to have ever been diagnosed with asthma or to still have asthma than their counterparts.[6,10,11] In addition to differences by demographics, obesity has been associated with asthma.[10–13] For example, one study reported that the prevalence of current asthma was higher among overweight/obese children compared with normal-weight children aged 2 to 19 years (13.2% vs 8.4%, respectively),[11] and another study found that US high school students with current asthma had a 40% greater likelihood of being obese than those without current asthma.[13]

Various factors have been associated with an increased risk for asthma, including exposure to tobacco smoke, allergens, and food preservatives.[14–16] For example, sodium benzoate is a preservative used in sodas and foods,[17] and negative reactions (eg, cough and/or wheeze) to sodium benzoate have been reported among asthmatic children and adults.[18,19] Although two studies reported that asthma symptoms were worsened by drinking sodas,[15,19] one study among New Zealand children found no association between “fizzy drinks” and ever having asthma after adjusting for lifestyle factors.[20] These inconsistent findings call for additional investigation because of the high consumption of soft drinks among US adolescents. The purpose of this cross-sectional analysis was to examine the association between regular-soda intake and current asthma after controlling for several potential confounders among a large, nationally representative sample of high school students. Authors hypothesized that daily soda intake would be associated with a greater odds of having current asthma.

METHODS

Sample and Survey Administration

This cross-sectional study is based on the 2009 national Youth Risk Behavior Survey (YRBS) data.[21] The national YRBS, a component of the Centers for Disease Control and Prevention (CDC)'s Youth Risk Behavior Surveillance System, is a school-based survey conducted biennially to monitor the prevalence of priority health risk behaviors among US high school students. In 2009, a three-stage cluster sample design was used to produce a nationally representative sample of students in grades 9 through 12 who attended public and private high schools in the 50 states and the District of Columbia. Sampling strategies and the psychometric properties of the questionnaire have been reported elsewhere.[22–24]

Student participation in the survey was anonymous and voluntary, and local parental permission procedures were followed. The CDC's Institutional Review Board approved the protocol for the national YRBS.[24] Students completed the 98-item self-administered paper questionnaire during a regular class period and recorded their responses directly on a computer-scannable questionnaire booklet or answer sheet. The school response rate was 81% (158 of the 196 sampled schools participated), the student response rate was 88% (16,460 of the 18,573 sampled students submitted questionnaires; 16,410 questionnaires were usable after data cleaning), and the overall response rate was 71%.[24] In addition, 450 students with a nonclassifiable response to questions about asthma (n = 412) and/or drinking regular soda (n = 38) were excluded. The proportion of the sample with unknown values or missing responses ranged from 0.4% to 7.3% for the other variables examined. For bivariate analyses, students with missing data for variables we were examining were excluded from analyses. For the multivariable logistic regression model, 14,108 students who had complete data on all variables of study were used. Compared to students excluded from the logistic regression model, students who were included in the logistic regression model were significantly older and disproportionately non-Hispanic white.

Variables

A previous study showed that YRBS survey questions demonstrated good test–retest reliability using 1999 YRBS data.[22] However, the validity for asthma and soda intake variables is not available because asthma and soda intake questions were not included in 1999 YRBS.[22] Of note, the validity of the soda-intake question is being assessed by the CDC. Based on unpublished data, soda intake from the survey questionnaire was significantly correlated with soda intake from 24-hour dietary recalls ($r = 0.44$) among high school students.

As the outcome of interest, current asthma was derived from a composite variable using the following questions: "Has a doctor or nurse ever told you that you have asthma?" and "Do you still have asthma?" Current asthma was defined as having a "yes" response to both of the preceding questions. Mutually exclusive response categories for each exposure and potentially confounding variable were created. The main exposure variable was regular-soda intake based on the question: "During the past 7 days, how many times did you drink a can, bottle, or glass of soda or pop, such as Coke [Coca-Cola Co], Pepsi [PepsiCo], or Sprite

[Coca-Cola Co]? (Do not include diet soda or diet pop.)" The following are the response options: I did not drink soda or pop during the past 7 days, one to three times during the past 7 days, four to six times during the past 7 days, one time per day, two times per day, three times per day, and four or more times per day. Data were analyzed using the following categories: none, one to three times per week, four to six times per week, one time per day, two times per day, and three or more times per day. Other covariates included were age (15 years or younger, 16 years, and 17 years or older); sex; race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic other); and current cigarette use (smoked cigarettes on at least 1 day during the 30 days before the survey) (no or yes). Self-reported weight and height were used to calculate body mass index (BMI) percentiles (based on age and sex). Weight status was classified based on BMI percentiles as defined by CDC growth charts: underweight/normal weight (<85th percentile), overweight (≥85th to <95th percentile), and obese (≥95th percentile).[25]

Statistical Analysis

χ^2 tests were used to examine the unadjusted association between regular-soda intake and current asthma. A P value <0.05 was considered statistically significant. A multivariable logistic regression model was used to estimate the adjusted odds ratios (ORs) and 95% CIs for the association of regular-soda intake with current asthma after controlling for the following potential confounding variables: age, sex, race/ethnicity, weight status, and current cigarette use. These specific potential confounders were selected based on previous research, which showed that regular-soda intake and/or asthma varied by age, sex, race/ethnicity, weight status, or smoking cigarettes.[8,24,26,27] Trend analysis was conducted to examine whether there is a positive dose–response relationship between soda intake and asthma using soda intake as an ordinal variable in the multivariable logistic regression analysis.

The data were weighted to adjust for nonresponse and oversampling of black and Hispanic students. To account for three-stage sample design, STRATA, CLUSTER, and WEIGHT statements were used in the analyses. All statistical analyses were performed with the Statistical Analysis Software (version 9.2, 2009, SAS Institute Inc) using appropriate procedures to account for complex sample design.

RESULTS AND DISCUSSION

The final analytic sample was 15,960 students. Characteristics of respondents are shown in Table 1. Overall, 10.8% of high school students reported having current asthma. In addition, the prevalence of current asthma varied significantly by regular-soda intake, sex, race/ethnicity, and current cigarette use (χ^2 tests, all $P \leq 0.03$). The prevalence of current asthma was 9.7% among students who did not drink regular soda, whereas, it was 14.7% among those who drank regular soda three or more times per day (Table 1).

Based on the bivariate logistic regression model, without controlling for other factors, odds of having current asthma was significantly higher among students who drank regular soda three or more times per day compared with those who did not drink regular soda. After controlling for age, sex, race/ethnicity, weight status, and current cigarette use, the

association persisted. The odds of having current asthma were significantly higher among students who drank regular soda two times per day (adjusted OR = 1.28) or three or more times per day (adjusted OR = 1.64) compared with those who did not drink regular soda (Table 2).

Similar to the present study, one national study reported that in 2009, 17.2% of US adolescents aged 12 to 17 years have ever been diagnosed with asthma, and 11.2% of adolescents still have asthma.[6] In the present study, the prevalence of current asthma was higher among students who had high regular-soda intake compared with those who did not drink regular soda during the 7 days before the survey. Consistent with our findings, a recent study conducted in 16,907 South Australians aged 16 years and older found that after controlling for sociodemographic and lifestyle factors, those who consumed high levels of soft drinks and sport drinks (≥0.5 L/day or 16.9 oz/day) had significantly greater odds for having asthma (adjusted OR = 1.26; 95% CI 1.01 to 1.58) compared with nonconsumers.[28]

In contrast to our findings, one study reported that after controlling for lifestyle factors, consuming fizzy drinks at least one time per week was not significantly associated with ever having asthma, ever wheezing, or wheezing during the last 12 months compared with those who never drank fizzy drinks, among 1,321 New Zealand children.[20] However, in that study, the highest fizzy drink intake category was one or more times per week, whereas it was three or more times per day in the present study. In the present study, there was no significant association between drinking regular soda more than zero to one or fewer times per day and current asthma, a suggestive finding at one time/day (adjusted OR = 1.28; 95% CI 0.99 to 1.66), but the association with asthma became significant when students drank regular soda two or more times per day. It is not clear whether a relationship between soda intake and asthma would have been found if that New Zealand study had included a greater sample size and/or higher levels of soda consumption.

One possible reason for finding the significant association between soda intake and current asthma might be the presence of food preservatives in sodas and other foods, such as sodium benzoate or sulphites (also sulfites).[17–19,29,30] Most sodas contain sodium benzoate as a preservative, which has been associated with worsening of asthma symptoms.[18,19] Evidence also suggests that asthma can be worsened by drinking sodas,[15,19] and a higher risk for asthma was associated with high intake of soft drinks and sport drinks.[28] One study found that adverse reactions were observed among 26.3% of asthmatic children aged 2 to 13 years after drinking beverages containing sodium benzoate.[19] Another study among schoolchildren in Greece reported that asthma symptoms were inversely associated with consumption of athletic refreshments that are not high in sulfur dioxide, but are positively associated with poor dietary habits, such as intake of cheese pie and chocolate milk that contain sulfur dioxide and other preservatives.[31]

Preservatives in sodas might not pose health hazards when they are consumed in minimal amounts. However, it could be postulated that when sensitive individuals consume a large amount (although an exact amount is unknown) of beverages/foods that contain food preservatives, such as sodium benzoate or sulfites,[18,19,29] they might pose health risks (eg, exacerbating or triggering asthma symptoms). In the present study, the consumption of

regular soda was relatively high: about one in three students reported drinking regular soda daily, and about one in five students reported drinking regular soda at least two times per day.

Additional research is needed to assess the longitudinal association and to understand the potential biochemical mechanisms for this association. However, considering other known adverse health consequences of soda and other calorically sweetened beverage intake, including obesity,[32–35] dental caries,[36] and displacement of nutrient-rich foods,[37,38] daily consumption of sodas should be discouraged among adolescents because they are the highest soda-consuming population group.[3] In order to decrease consumption of soda and other calorically sweetened beverages among adolescents, multiple strategies limiting availability and accessibility of calorically sweetened beverages are needed in various settings (eg, homes, schools, and communities).

The strength of this study is that it is based on a large, nationally representative sample with a relatively high response rate. However, this study is subject to limitations. First, the associations are cross-sectional and do not permit identifying the direction of these associations or causality. Second, YRBS is based on self-report, so there is the potential for reporting bias for asthma, soda intake, cigarette smoking, and weight status. Third, other possible confounders for asthma (eg, socioeconomic status, family history of asthma, current health status, and certain environmental factors) and severity of asthma could not be accounted for because these data were not available. Fourth, regular sodas are only one food category that could contribute preservatives. Diet sodas and other foods that contain preservatives were not included in this study because YRBS does not collect this information. However, in 2010, only about 7% of US high school students reported drinking diet soda daily.[4] Fifth, there was no measure of portion size for soda intake. However, the soda question provided a semi-quantitative measure, such as a can, bottle, or glass. Lastly, our findings apply only to adolescents who attend school and, therefore, are not representative of all people in this age group. However, in 2008, only about 4% of youth aged 16 to 17 years nationwide had not completed high school and were not enrolled in a high school program.[39]

CONCLUSIONS

This analysis indicates that drinking regular soda at least two times per day was significantly associated with greater odds for current asthma after controlling for potential confounders. Efforts to reduce regular-soda intake among youth might have benefits beyond improving diet quality. However, this association needs to be examined longitudinally and the biochemical mechanisms need to be elucidated.

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Table 1

Selected characteristics of respondents and associations between respondents' characteristics and current asthma[a] status among US high school students, Youth Risk Behavior Survey, 2009

			Current Asthma				
	All Respondents		No		Yes		
Characteristic	**%[b]**	**95% CI**	**%[b]**	**95% CI**	**%[b]**	**95% CI**	***P* value[c]**
Total sample (N = 15,960)[d]	100		89.2	88.3–90.1	10.8	9.9–11.7	—
Regular-soda intake[e] (n = 15,960)							
None	19.4	18.2–20.7	90.3	88.8–91.9	9.7	8.1–11.2	0.0001
1–3 times/wk	33.0	31.5–34.5	89.8	88.6–90.9	10.2	9.1–11.4	
4–6 times/wk	18.5	17.5–19.5	90.6	89.2–91.9	9.4	8.1–10.8	
1 time/day	9.5	8.6–10.4	88.0	85.5–90.5	12.0	9.5–14.5	
2 times/day	8.5	7.7–9.3	88.3	86.0–90.6	11.7	9.4–14.0	
≥3 times/day	11.1	9.6–12.5	85.3	82.8–87.9	14.7	12.1–17.2	
Age (n = 15,893)							
≤15 y	36.2	34.3–38.1	89.1	87.9–90.4	10.9	9.6–12.1	0.34
16 y	25.9	24.7–27.1	88.6	87.4–89.9	11.4	10.1–12.6	
≥17 y	37.9	36.1–39.7	89.7	88.5–91.0	10.3	9.0–11.5	
Sex (n = 15,898)							
Female	48.1	45.5–50.6	88.4	87.3–89.5	11.6	10.5–12.7	0.02
Male	51.9	49.4–54.5	90.0	88.8–91.2	10.0	8.8–11.2	
Race/ethnicity (n = 15,679)							
Non-Hispanic white	59.1	53.0–65.1	89.2	87.8–90.6	10.8	9.4–12.2	0.01
Non-Hispanic black	14.2	11.2–17.3	87.5	85.8–89.2	12.5	10.8–14.2	
Hispanic	18.4	15.5–21.3	91.0	89.8–92.3	9.0	7.7–10.2	
Non-Hispanic other[f]	8.3	5.2–11.3	88.0	85.9–90.0	12.0	10.0–14.1	
Weight status[g] (n = 14,794)							
Underweight/normal weight	72.4	70.9–73.9	89.5	88.3–90.7	10.5	9.3–11.7	0.48
Overweight	15.7	14.6–16.8	88.6	86.5–90.7	11.4	9.3–13.5	
Obesity	11.9	10.8–13.0	88.3	86.5–90.1	11.7	9.9–13.5	

	All Respondents		Current Asthma				
			No		Yes		
Characteristic	**%[b]**	**95% CI**	**%[b]**	**95% CI**	**%[b]**	**95% CI**	***P* value[c]**
Smoked cigarettes on ≥1 day past 30 days (n = 15,356)							
No	80.7	79.1–82.4	89.5	88.6–90.4	10.5	9.6–11.4	0.03
Yes	19.3	17.6–20.9	88.0	86.4–89.5	12.0	10.5–13.6	

[a] Had been told by a doctor or nurse that they had asthma and still have asthma.

[b] Weighted percentage is presented.

[c] χ^2 tests were used for each variable to examine differences across categories.

[d] Unweighted sample size is presented.

[e] Drinking a can, bottle, or glass of soda (not including diet soda) during the 7 days before the survey.

[f] Non-Hispanic other includes non-Hispanic American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, or multiracial.

[g] Underweight/normal weight was defined as body mass index (BMI) <85th percentile; overweight was defined as BMI ≥ 85th to < 95th percentile; and obesity was defined as BMI ≥ 5th percentile, all based on the Centers for Disease Control and Prevention's 2000 growth charts.

Table 2

The relationship between current asthma[a] and regular-soda intake[b] among US high school students

	Respondents with Current Asthma			
	Crude odds ratio[c]	**95% CI**	**Adjusted odds ratio[d]**	**95% CI**
Regular-soda intake[e]				
None	Reference	—	Reference	—
1–3 times/wk	1.06	0.91–1.25	1.10	0.94–1.30
4–6 times/wk	0.97	0.77–1.22	1.04	0.83–1.31
1 time/day	1.27	0.95–1.69	1.28	0.99–1.66
2 times/day	1.23	0.99–1.54	1.28[f]	1.02–1.62
≥3 times/day	1.60[f]	1.24–2.07	1.64[f]	1.25–2.16

[a] Had been told by a doctor or nurse that they had asthma and still have asthma.

[b] Drinking a can, bottle, or glass of soda (not including diet soda) during the 7 days before the survey.

[c] Drinking a can, bottle, or glass of soda (not including diet soda) during the 7 days before the survey.

[d] Multivariable logistic regression model included a sample of 14,108 students without missing data and odds ratios are adjusted for age, sex, race/ethnicity, weight status, and current cigarette use. Reference category included students who did not have asthma.

[e] *P* value for trend was <0.05.

[f] Significant finding based on the 95% CI (ie, the CI does not include 1).